

WHAT IS CLAIMED IS:

1. A gap adjustment apparatus comprising:
  - a first stage defining a first reference surface;
  - 5 a second stage defining a second reference surface, the second stage being opposite to the first stage in a manner such that the second reference surface becomes parallel to the first reference surface;
    - a first chuck for fixing a first object having a main surface on the first stage, in a manner such that the main surface of the first object faces towards the
    - 10 second stage and becomes parallel to the first reference surface;
      - a first displacement sensor attached on the first stage and adapted to measure a distance between the first displacement sensor and a certain plane disposed in front of the first displacement sensor and parallel to the second reference surface;
      - 15 a second chuck for fixing a second object having a main surface on the second stage, in a manner such that the main surface of the second object faces towards the first stage and becomes parallel to the second reference surface;
        - a second displacement sensor attached on the second stage and capable of measuring a distance between the second displacement sensor and a certain
        - 20 plane disposed in front of the second displacement sensor and parallel to the first reference surface;
        - an eddy current sensor attached on the first stage and having a sensor reference surface parallel to the first reference surface;
        - an eddy current sensor target attached on the second stage and having a
        - 25 target reference surface parallel to the second reference surface;
        - a moving mechanism for moving one of the first stage and the second

stage in a direction parallel to the first reference surface and in another direction perpendicular to the first reference surface, with the movement of one stage being relative to the other stage;

- a controller which is adapted to drive the moving mechanism in a manner
- 5 such that the target can be located in front of the first displacement sensor, to measure a distance extending from the first displacement sensor to the target reference surface of the target, to drive the moving mechanism in a manner such that the second main surface can be located in front of the first displacement sensor, to measure a distance extending from the first displacement sensor to the
- 10 second main surface, to drive the moving mechanism in a manner such that the eddy current sensor can be located in front of the second displacement sensor, to measure a distance extending from the second displacement sensor to the sensor reference surface of the eddy current sensor, to drive the moving mechanism in a manner such that the first main surface can be located in front of
- 15 the second displacement sensor, to measure a distance extending from the second displacement sensor to the first main surface, to drive the moving mechanism in a manner such that the target can be located in front of the eddy current sensor, and to measure an distance between the sensor reference surface and the target reference surface.

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2. A gap adjustment apparatus according to claim 1, further comprising:

a first height adjusting mechanism capable of adjusting a height from the first reference surface to the sensor reference surface of the eddy current sensor; and

- 25 a second height adjusting mechanism capable of adjusting a height from the second reference surface to the target reference surface of the target;

wherein the controller is adapted to drive the second height adjusting mechanism in accordance with a measurement result of the first displacement sensor, in a manner such that the height from the second reference surface to the target reference surface becomes equal to a height from the second reference surface to the main surface of the second object, and to drive the first height adjusting mechanism in accordance with a measurement result of the second displacement sensor, in a manner such that the height from the first reference surface to the sensor reference surface becomes equal to a height from the first reference surface to the main surface of the first object.

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3. A gap adjustment method comprising:

a first step of fixing a first object on a first stage defining a first reference surface, in a manner such that a main surface of the first object becomes parallel to the first reference surface;

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a second step of fixing a second object on a second stage defining a second reference surface parallel to the first reference surface, in a manner such that a main surface of the second object becomes parallel to the second reference surface;

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a third step of calculating or adjusting a relationship between a sensor reference surface's height from the first reference surface and a height from the first reference surface to the main surface of the first object, a position of the sensor reference surface being fixed relative to a reference surface of an eddy current sensor attached on the first stage;

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a fourth step of calculating or adjusting a relationship between a target reference surface's height from the second reference surface and a height from the second reference surface to the main surface of the second object, the target

reference surface being a target reference surface of an eddy current sensor target being fixed relative to the second stage; and

- a fifth step of measuring a distance extending from the sensor reference surface of the eddy current sensor to the target reference surface, and for
- 5 adjusting a distance between the first stage and the second stage so as to enable a measurement result to be closer to a desired value.

4. A gap adjustment method according to claim 3, wherein the third step is provided to effect an adjustment such that the sensor reference surface and the
- 10 main surface of the first object can be in exactly the same plane, while the fourth step is provided to effect an adjustment such that the target reference surface and the main surface of the second object can be in exactly the same plane.

5. A gap adjustment apparatus comprising:
- 15 a mask chuck for holding a mask having a mask pattern formed thereon;  
a first leveling mechanism for holding the mask chuck and capable of moving the mask chuck in a first direction perpendicular to a surface on which the mask pattern of the mask fixed on the mask chuck has been formed;  
a mask stage for supporting the first leveling mechanism;
- 20 a wafer chuck for holding the wafer in a manner such that an exposure surface of the wafer is caused to face towards the mask;  
a second leveling mechanism capable of moving the wafer chuck in the first direction;
- a wafer stage for holding the second leveling mechanism;
- 25 a first distance sensor attached on the mask stage and capable of measuring a distance in the first direction, the distance extending to the exposure

surface of the wafer held on the wafer chuck; and

a second distance sensor attached on the wafer stage and capable of measuring a distance in the first direction, the distance extending to the surface of the mask fixed on the mask chuck, and also capable of measuring another  
5 distance in the first direction, the other distance extending to the first distance sensor.

6. A gap adjustment apparatus according to claim 5, further comprising a first two-axis moving mechanism which is so formed that when the relative positions  
10 of the mask chuck and the first distance sensor have been fixed, both the mask chuck and the first distance sensor are moved in a direction perpendicular to the first direction.

7. A gap adjustment apparatus according to claim 5, further comprising a  
15 second two-axis moving mechanism for moving the wafer in a direction perpendicular to the first direction, without having to move the second sensor.

8. A gap adjustment apparatus according to claim 6, further comprising a second two-axis moving mechanism for moving the wafer in a direction  
20 perpendicular to the first direction, without having to move the second sensor.

9. A gap adjustment apparatus according to claim 5, further comprising a controlling device such that when  $D_A$  represents a distance extending from the second distance sensor to the first distance sensor,  $D_B$  represents a distance  
25 extending from the second distance sensor to the surface of the mask, and  $D_D$  represents a distance extending from the first distance sensor to the exposure

surface of the wafer,  $D_D - (D_A - D_B)$  is compared with a desired value, and the first leveling mechanism or the second leveling mechanism is operated so that  $D_D - (D_A - D_B)$  becomes closer to the desired value.

- 5 10. A gap adjustment apparatus according to claim 6, further comprising a controlling device such that when  $D_A$  represents a distance extending from the second distance sensor to the first distance sensor,  $D_B$  represents a distance extending from the second distance sensor to the surface of the mask, and  $D_D$  represents a distance extending from the first distance sensor to the exposure
- 10 surface of the wafer,  $D_D - (D_A - D_B)$  is compared with a desired value, and the first leveling mechanism or the second leveling mechanism is operated so that  $D_D - (D_A - D_B)$  becomes closer to the desired value.

11. A gap adjustment method comprising:
- 15 a step of disposing a first measurement object having a first surface and a second measurement object having a second surface so that the first surface and the second surface face each other, in a manner such that the first surface of the first measurement object and the second surface of the second measurement object become perpendicular to a first direction;
- 20 a step of measuring a distance  $D_A$  in the first direction, the distance extending from a first distance sensor to a second distance sensor;
- a step of measuring a distance  $D_B$  in the first direction, the distance extending from the second distance sensor to the surface of the first measurement object;
- 25 a step of measuring a distance  $D_D$  in the first direction, the distance extending from the first distance sensor to the second surface of the second

measurement object; and

a step of moving at least one of the first measurement object and the second measurement object in the first direction to make  $D_D - (D_A - D_B)$  closer to a desired value.

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12. A gap adjustment apparatus comprising:

a first holding member for fixing and holding a first measurement object having a first surface;

a first leveling mechanism capable of holding the first holding member and  
10 moving the first holding member in a first direction perpendicular to the first surface of the first measurement object fixed on the first holding member;

a first stage for holding the first leveling mechanism;

a second holding member for holding a second measurement object  
having a second surface, in a manner such that second surface faces towards  
15 the first surface;

a second leveling mechanism capable of moving the second holding member in the first direction;

a second stage for holding the second leveling mechanism;

a first distance sensor attached on the first stage, capable of measuring a  
20 distance in the first direction extending to the second surface of the second measurement object fixed on the second holding member; and

a second distance sensor attached on the second stage, for measuring a distance in the first direction extending to the first surface of the first measurement object fixed on the first holding member, and another distance in  
25 the first direction extending to the first distance sensor.

13. A gap adjustment apparatus comprising:
- a first holder for holding a first object having a first measurement surface;
  - a second holder for holding a second object having a second measurement surface, in a manner such that the second measurement surface
- 5 faces the first measurement surface;
- a first displacement gauge for measuring a distance extending from the first displacement gauge to the first measurement surface;
  - a target whose relative position with respect to the first displacement gauge is fixed, the target having a target measurement surface orientated in the
- 10 same direction as the second measurement surface;
- a second displacement gauge for measuring distances extending from the second displacement gauge to the second measurement surface and to the target measurement surface; and
  - a moving mechanism for moving at least one of the first holder and the
- 15 second holder, in order to alter a gap between the first measurement surface and the second measurement surface.
14. A gap adjustment apparatus according to claim 13, wherein the first displacement gauge is disposed on the outside of a displacement amount
- 20 detectable range of the second displacement gauge, the second displacement gauge is disposed on the outside of a displacement amount detectable range of the first displacement gauge.
15. A gap adjustment apparatus according to claim 13, wherein the first
- 25 displacement gauge and the second displacement gauge are all electrostatic capacity type displacement gauges.



16. A gap adjustment apparatus according to claim 13, further comprising a controller capable of driving the moving mechanism in accordance with a calculation result calculated by using an equation  $D_A + D_D - (D_B + D_C)$  in which  $D_A$  is a distance extending from the second displacement gauge to the second measurement surface,  $D_B$  is a distance extending from the second displacement gauge to the target measurement surface,  $D_C$  is a distance extending from the first displacement gauge to the target measurement surface,  $D_D$  is a distance extending from the first displacement gauge to the first measurement surface.
17. A gap adjustment apparatus according to claim 13, wherein one of the first object and the second object is a mask for use in the electron beam proximity exposure, the other of the first object and the second object is a wafer to be subjected to the exposure treatment, the apparatus further comprising:
- an electron gun for emitting an electron beam; and
  - an electron beam controller for controlling the electron beam, in a manner such that the electron beam emitted from the electron gun is enabled to pass through the mask so as to irradiate the wafer.
18. A gap adjustment method comprising the steps of:
- holding a first object having a first measurement surface and a second object having a second measurement surface, in a manner such that the second measurement surface is caused to face the first measurement surface;
  - using a first displacement gauge to measure a distance  $D_D$  extending from the first displacement gauge to the first measurement surface;
  - using a second displacement gauge to measure a distance  $D_A$  extending

from the second displacement gauge to the second measurement surface; and

- using a distance  $D_B$  extending from the second displacement gauge to a target measurement surface whose relative position with respect to the first displacement gauge is fixed, a distance  $D_C$  extending from the first displacement
- 5 gauge to the target measurement surface, as well as the distance  $D_D$  and the distance  $D_A$  to calculate  $D_A + D_D - (D_B + D_C)$  and obtain a gap between the first measurement surface and the second measurement surface.

19. A gap adjustment method according to claim 18, wherein before calculating
- 10 a gap between the first measurement surface and the second measurement surface, the second displacement gauge is used to measure a distance  $D_B$  extending from the second displacement gauge to the target measurement surface.

- 15 20. A gap adjustment method comprising the steps of:

holding a first object having a first measurement surface and a second object having a second measurement surface, in a manner such that the second measurement surface is caused to face the first measurement surface;

- using a first displacement gauge to measure a distance  $D_D$  extending from
- 20 the first displacement gauge to the first measurement surface;

using a second displacement gauge to measure a distance  $D_A$  extending from the second displacement gauge to the second measurement surface;

- using a distance  $D_B$  extending from the second displacement gauge to a target measurement surface whose relative position with respect to the first
- 25 displacement gauge is fixed, a distance  $D_C$  extending from the first displacement gauge to the target measurement surface, the distance  $D_D$  and the distance  $D_A$ ,

so as to obtain an information specifying a gap between the first measurement surface and the second measurement surface;

using the information specifying the gap between the first measurement surface and the second measurement surface to move at least one of the first  
5 object and the second object, in a manner such that the gap between the first measurement surface and the second measurement surface can be changed.

21. A gap adjustment method according to claim 20, wherein before obtaining the information specifying the gap between the first measurement surface and  
10 the second measurement surface, the second displacement gauge is used to measure a distance  $D_B$  extending from the second displacement gauge to the target measurement surface.

22. A gap adjustment apparatus comprising:  
15 a first holder for holding a first object having a first measurement surface;  
a second holder for holding a second object having a second measurement surface, in a manner such that the second measurement surface is caused to face the first measurement surface;

a first displacement gauge disposed to face the first measurement surface,  
20 for measuring a distance extending from the first displacement gauge to the first measurement surface;

a second displacement gauge disposed to face the second measurement surface, for measuring a distance extending from the second displacement gauge to the second measurement surface as well as a distance extending from  
25 the second displacement gauge to the first displacement gauge;

a moving mechanism for moving at least one of the first holder and the

second holder, so as to alter a gap between the first measurement surface and the second measurement surface.

23. A gap adjustment method comprising the steps of:

- 5 holding a first object having a first measurement surface and a second object having a second measurement surface, in a manner such that the second measurement surface is caused to face the first measurement surface;  
using a first displacement gauge facing the first measurement surface, to measure a distance  $D_D$  extending from the first displacement gauge to the first  
10 measurement surface;  
using a second displacement gauge facing the second measurement surface, to measure a distance  $D_A$  extending from the second displacement gauge to the second measurement surface;  
using a distance  $D_E$  extending from the first displacement gauge to the  
15 second displacement gauge, the distance  $D_D$  and the distance  $D_A$ , to calculate  $D_A + D_D - D_E$  and obtain a gap between the first measurement surface and the second measurement surface.

24. A gap adjustment method comprising the steps of:

- 20 holding a first object having a first measurement surface and a second object having a second measurement surface, in a manner such that the second measurement surface is caused to face the first measurement surface;  
using a first displacement gauge facing the first measurement surface, to measure a distance  $D_D$  extending from the first displacement gauge to the first  
25 measurement surface;  
using a second displacement gauge facing the second measurement

surface, to measure a distance  $D_A$  extending from the second displacement gauge to the second measurement surface;

obtaining an information specifying a gap between the first measurement surface and the second measurement surface, in accordance with a distance  $D_E$

5 extending from the first displacement gauge to the second displacement gauge,  
as well as the distance  $D_D$  and  $D_A$ ;

using the information specifying the gap between the first measurement surface and the second measurement surface to move at least one of the first object and the second object, in a manner such that the gap between the first

10 measurement surface and the second measurement surface can be changed.